OregonWaveEnergy TRUST

Apr | 10

Cumulative Impacts of Wave Energy In Oregon

A Literature and Research Review

Prepared by
Aquatera Ltd
In partnership with Parametrix
In collaboration with Powertech and European Marine Energy Centre
On behalf of Oregon Wave Energy Trust

This work was funded by the Oregon Wave Energy Trust (OWET). OWET was funded in part with Oregon State Lottery Funds administered by the Oregon Business Development Department. It is one of six Oregon Innovation Council initiatives supporting job creation and long-term economic growth.

Oregon Wave Energy Trust (OWET) is a nonprofit public-private partnership funded by the Oregon Innovation Council. Its mission is to support the responsible development of wave energy in Oregon. OWET emphasizes an inclusive, collaborative model to ensure that Oregon maintains its competitive advantage and maximizes the economic development and environmental potential of this emerging industry. Our work includes stakeholder outreach and education, policy development, environmental assessment, applied research and market development.

This work was funded by the Oregon Wave Energy Trust (OWET).

OWET was funded in part with Oregon State Lottery Funds administered by the Oregon Business Development Department. It is one of six Oregon Innovation Council initiatives supporting job creation and long term economic growth.

This document was prepared by Aquatera Ltd on behalf of the Oregon Wave Energy Trust.

For information about this project, please contact Gareth Davies at Aquatera Ltd:

Phone: (011-44)1856 850 088
Fax: (011-44)1856 850 089
Email: office@aquatera.co.uk

About Oregon Wave Energy Trust

The Oregon Wave Energy Trust – (OWET) - with members from fishing and environmental groups, industry and government - is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. Its mission is to serve as a connector for all stakeholders involved in wave energy project development - from research and development to early stage community engagement and final deployment and energy generation - positioning Oregon as the North America leader in this nascent industry and delivering its full economic and environmental potential for the state. OWET's goal is to have ocean wave energy producing 2 megawatts of power - enough to power about 800 homes - by 2010 and 500 megawatts of power by 2025.

Contents

Page

Introduction

Aquatera, Parametrix, European Marine Energy Centre (EMEC) and Powertech Labs have been contracted by the Oregon Wave Energy Trust (OWET) to develop and deliver a framework suitable for identifying and assessing potential cumulative impacts from the development of a wave energy industry in Oregon and for use in evaluating the policy implications of wave energy development relative to natural resource planning.

The framework will essentially provide a means for geographically managing interactions, conflicts and opportunities based on geographic distribution data. The resulting framework will have a wide range of possible applications after further development including:

- Regulators identifying, assessing and managing impacts and opportunities
- Developers identifying areas particularly suitable for development
- Stakeholders identifying potential areas of overlap and opportunity
- Strategic planners identifying potential development areas and potential areas of conflict
- Conflict management, consultation, marine management and public awareness

One task associated with the development of this framework is to conduct a global literature review of relevant data and information to help build the cumulative effects framework. Some relatively recent work relevant to this task includes an exhaustive literature review on wave and tidal energy applications in the Pacific Northwest completed by Powertech (Powertech Labs Inc., 2008) and a synthesis of information regarding the environmental effects of alternative energy uses commissioned by the Minerals Management Service (Michel, 2007).

This document adds to those existing reviews through providing a summary of similar work which is underway or has been completed around the world, as well as work that is currently underway that has the potential to inform future iterations of the framework that will be developed during this stage of the project, Phase I.

1 Strategic marine planning and management

The cumulative effects framework is designed as a strategic marine planning tool that can be used to identify and assess potential cumulative impacts from the development of wave energy as well as to evaluate policy implications of wave energy development relative to natural resource planning. Other strategic marine planning and management tools which are currently being implemented around the world include:

- Marine spatial planning
- Marine management plans
- Environmental assessments

In the following sections, each of these processes will be described in more detail and its relevance to the cumulative effects framework discussed.

1.1 Marine Spatial Planning

Marine spatial planning (MSP) is a tool being used for spatial allocation of activities in the marine environment in order to manage user conflicts, protect the environment, and/or establish a long-term vision for regulating activities. Although there is no one definition for MSP, the UNESCO marine spatial planning initiative defines MSP as, "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process (UNESCO, 2009)." MSP is generally performed on the basis of national legislation or a strong national policy. There is no international legislation requiring MSP, although the 1982 Law of the Sea Convention (UNCLOS) provides the legal basis for sea exploitation, the right to allocate activities and the duty to protect the marine environment, and some coastal states have taken MSP initiatives in their maritime areas.

Marine spatial planning is ecosystem-based (i.e. it recognizes the full array of interactions within an ecosystem, including humans) and aims to address the cumulative effects of multiple human uses of the same marine space. It is also area-based in that it focuses on a specific ecosystem and the human activities affecting it.

Marine spatial planning actively involves stakeholders in the process and is an iterative process that can be adapted over time. Over time the many aspects of the environment will change (such as the social, political, economic environment) as well as our knowledge and the technology available to us. Therefore a marine spatial management plan must also be capable of being adaptive and should be updated periodically to reflect changing circumstances.

Relevance to the Framework

The cumulative effects framework will assist in Marine Spatial Planning initiatives by providing a way to visualize existing resources, uses and sensitivities in the marine environment and to assess and manage areas of potential conflict and opportunity. Like MSP, the cumulative effects framework should be strategic, area-based, integrated, adaptive, and participatory.

1.1.1 Marine planning policy in the US

In December 2009, the Interagency Ocean Policy Task Force issued an *Interim Framework for Effective Coastal and Marine Spatial Planning* (Interagency Ocean Policy Task, 2009). This report defines the geographic scope of Coastal and Marine Spatial Planning (CMSP) and proposes nine regional planning areas. The framework articulates national CMSP goals

and guiding principles, outlines the process for engaging in CMSP, and provides a plan for implementation.

Past marine spatial planning initiatives undergone by inidividual states include the Florida Blueways Project, Florida Keys National Marine Sanctuary, Gulf of Maine Mapping Initiative, the Massachusetts Oceans Act, and the Oregon Territorial Sea Plan (NOAA Office of Ocean and Coastal Resource Management 2009; Marine Spatial Planning Initiative 2009; Oregon Coastal Management Program 1994). Oregon's Territorial Sea Plan process is described below.

1.1.2 Oregon Territorial Sea Plan

In 1987, the Oregon State Legislature created an Ocean Resources Task Force tasked with preparing policy and program recommendations in response to federal proposals for ocean oil, gas, and hard mineral leasing during the Reagan Administration. The Task Force compiled an extensive set of policy recommendations in the Oregon Ocean Resources Management Plan completed in 1990.

The 1991 Legislature recognized that these policies should be the starting point for a specific plan and policies aimed at Oregon's Territorial Sea and passed the Oregon Ocean Resources Management Act. This law created the Ocean Policy Advisory Council (OPAC) to give coordinated policy advice to the Governor, state agencies, and others and to prepare a plan for Oregon's Territorial Sea. The Territorial Sea Plan was adopted in 1994 and applies to state and federal agency programs and activities that take place over a three nautical-mile wide strip of ocean water adjacent to the shore (Oregon Coastal Management Program 2008).

The Territorial Sea Plan is a comprehensive plan focusing on integrating ocean management to best conserve ocean resources for current and future generations. The Plan sets up procedures and standards for decision makers to balance competing uses, and prioritizes the protection of renewable marine resources over the development of non-renewable ocean resources. The plan also supports development of ocean resources that is environmentally sound and economically beneficial to Oregonians and protects the health of the marine environment (NOAA Office of Ocean and Coastal Resource Management 2009).

The State of Oregon has recently adopted a chapter for the Territorial Sea Plan addressing development of renewable energy facilities or other related structures, equipment or facilities (Oregon Department of Land Conservation and Development, 2009). This chapter includes policies related to authorizing the siting, development and operation of renewable energy facilities within the Oregon Territorial Sea, and implementation requirements for these policies that require a resource inventory and effects evaluation prepared by the applicant, as well as an operation plan as a condition of approval.

Relevance to the framework

The framework specifically addresses the requirement in the Oregon Territorial Sea Plan to evaluate cumulative effects. The Framework will therefore need to be consistent with the Policies of this Plan and compatible with the Implementation Requirements therein.

1.1.3 Other Examples of Marine Spatial Planning

The Marine and Coastal Access Act and parallel Scottish Marine Bill (see below) include provisions for establishing a new UK-wide system of marine planning, to enable more strategic management of the seas. Objectives include creating a new marine planning system and providing an umbrella body which has responsibility for the marine environment. These new laws will create a strategic marine planning system that will clarify the Government's marine objectives and priorities for the future, and direct decision-makers and

users toward more efficient, sustainable use, and protection of marine resources of the UK. The first stage of this marine planning system would be the creation of a UK-wide Marine Policy Statement to create a more integrated approach to marine management and setting both short and longer-term objectives for sustainable use of the marine environment. A series of marine plans would then be created in a second stage, which would implement the policy statement in specific areas, using information about spatial uses and needs in those areas (UNESCO, 2009). A schematic of the marine spatial planning scheme is shown in Figure 1.1.

In spring 2006, the Norwegian government presented an integrated management plan for the Norwegian part of the Barents Sea, covering 1,400,000 km2—about four times the size of Norway's land area. The plan provides a framework for managing all human activities (oil and gas industry, fishing, and shipping) in the area to ensure the continued health, production, and function of the Barents Sea ecosystem. Four extensive government-funded Environmental Impact Assessments (EIAs) were carried out, covering the impact of fisheries, shipping, hydrocarbon extraction, and external pressures (e.g. pollution) on the environment, resources, and local communities (UNESCO 2010).

Germany, Belgium and the Netherlands all have small but very heavily used seas and have therefore implemented marine spatial plans which aim to manage their economic, ecological and social objectives. Among the issues considered are the identification of areas of opportunity for offshore wind farm development (BSH 2009; Dutch Ministry of Transport, Public Works and Water Management 2005).

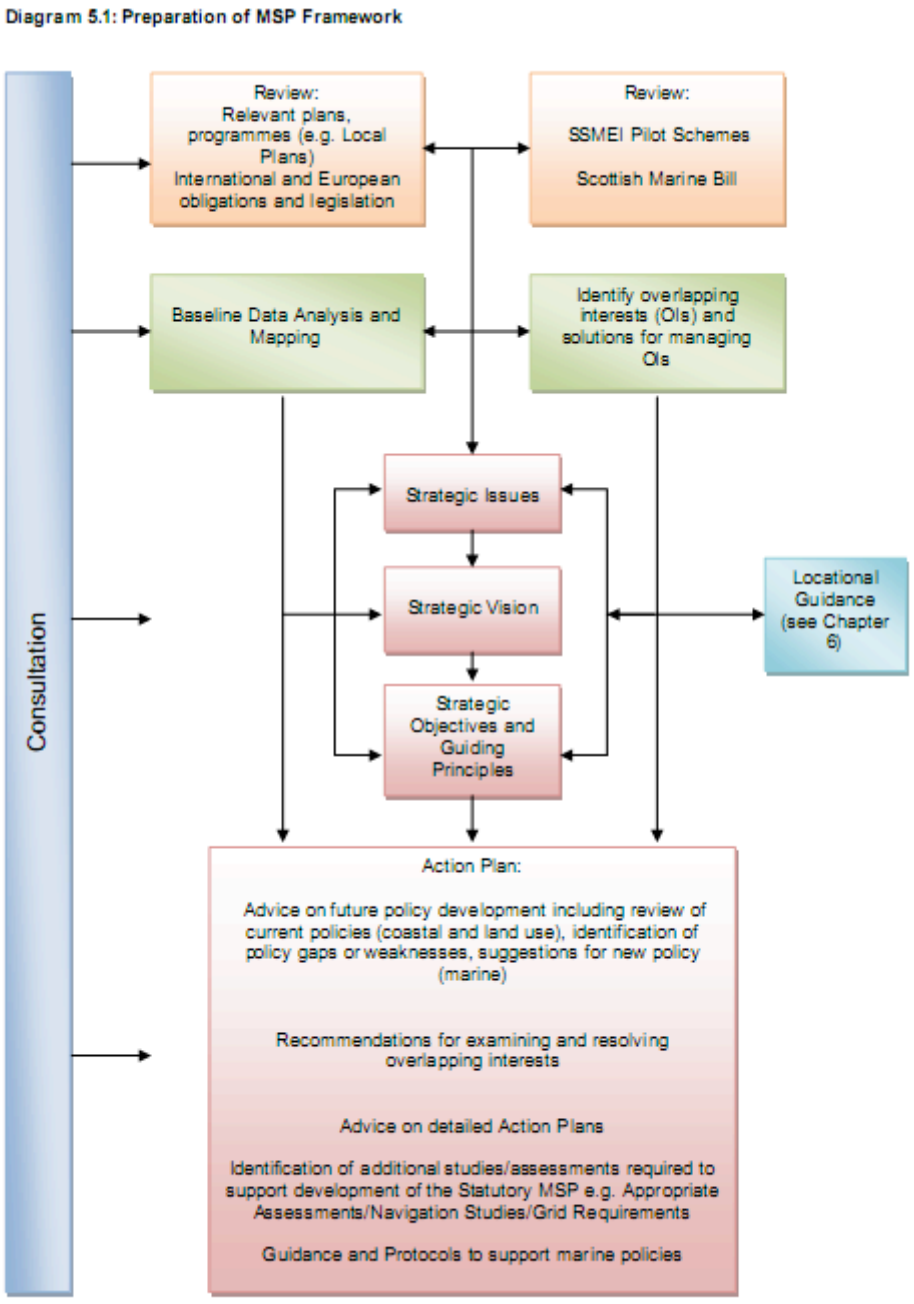

Figure 1.1 Schematic of UK marine spatial planning framework (from: AECom 2009)

The Wadden Sea Area covers a large part of the West coast of Denmark, the German North Sea Coast as well as a large part of the Netherlands' coast and is an important wetland area. Since 1978, the responsible ministries of The Netherlands, Denmark and Germany have been working together on the protection and conservation of the Wadden Sea. The Trilateral Wadden Sea Plan was adopted in October 1997 (Common Wadden Sea Secretariat, 1997; Common Wadden Sea Secretariat ,2009).

Other countries such as Australia have not yet gone down the route of marine spatial plans but have marine bioregional plans which are being developed for Australia's five marine regions. The plans will describe each region's key habitats, plants and animals, natural processes, human uses and benefits, and threats to the long-term ecological sustainability of the region. The bioregional plans will provide the platform for developing Marine protected

areas (Australian Government Department of the Environment, Water, Heritage, and the Arts, 2009).

1.2 Marine Management Plans

There are examples of other countries around the world which have policies or are in the process of developing policies in order to integrate / manage newly developing offshore energy sectors more effectively. Of particular interest are those countries in which a wave energy industry is developing or is likely to develop in the near future.

1.2.1 Canada Oceans Act

In 1997, by passing its Oceans Act, Canada became the first country in the world to adopt comprehensive legislation for integrated ocean management. Five Large Ocean Management Areas (LOMAs) have been identified to address large-scale ocean space issues and provide the context for future integrated management and spatial planning (Fisheries and Oceans Canada, 2009). In addition Canada's marine spatial framework is further developed around 19 ecological units (marine eco-regions) identified on the basis of a set of criteria and delineated to ensure that management areas capture ecosystem-scale features, patterns and trends. A strategic plan for integrated ocean management for the Eastern Scotian Shelf was published in 2007 (Fisheries and Oceans Canada, 2008; Fisheries and Oceans Canada, 2007) and an integrated management plan for the Beaufort Sea is in its final stage of development (Beaufort Sea Partnership, n.d.).

1.2.2 United Kingdom -- The Marine Bill

The Marine and Coastal Access Act was approved by the UK Parliament in November 2009, and a parallel Scottish Marine Bill was adopted by the Scottish parliament in February 2010. The marine bill introduces a range of policies which aim to protect the natural environment and allow growth of marine industries (The Scottish Government, 2010; DEFRA, 2009). In addition to creating a new marine planning system, as discussed above, the bill will provide an umbrella body which will have responsibility for the marine environment, and introduce new tools for conservation, sustainable management of fisheries, coastal access and coastal and estuary management.

1.3 Strategic Environmental Assessment

Another management tool for the marine environment is the environmental assessment. An environmental assessment is a procedure in which data are gathered on the environment potentially impacted by a project, plan or programme (such as marine energy development). These data are then evaluated to determine the interactions between the development and the environment that are expected to be the most significant. A consultation is carried out on the draft plan or programme and the results of this and the environmental report are taken into account in decision-making. This tool can inform the development of marine spatial plans as well as strategies for the development of marine energy.

Under the National Environmental Policy Act, agencies must consider the environmental impacts of a proposed activity, plan or programme, explore feasible alternatives, document the likely environmental consequences and make this information available to the public in either Environmental Assessments (EAs) or Environmental Impact Statements (EISs). Similarly, in Europe, the European Parliament Directive 2001/42 EC, usually referred to as the SEA Directive, requires environmental assessments to be carried out for a range of plans and programmes likely to have significant effects on the environment. There are similar laws and requirements in other countries, and the format of these is similar across the world. In the EU, environmental assessments include a description of the project or programme, an examination of alternatives, a description of the environment, an assessment

of the significant effects on the environment, and an explanation of mitigating measures that will be taken to reduce negative impacts.

A number of countries/ regions have undertaken broad environmental assessments of the marine environment in order to assess the potential environmental impacts of marine renewable energy.

- A final programmatic EIS in support of the establishment of a program for authorizing alternative energy and alternate use (AEAU) activities on the Outer Continental Shelf (OCS) has been prepared by the United States Department of the Interior, Minerals Management Service (MMS) (USDI Minerals Management Service, n.d.).
- In Scotland, the Scottish Marine Renewables SEA is a strategic environmental assessment carried out for the north and west coast of Scotland (Faber Maunsell/AECom, 2008).
- A Strategic environmental assessment has been carried out in support of the development of tidal energy in the Bay of Fundy (OEER Association, 2008).
- Ireland is planning to undertake of a Strategic Environmental Assessment for ocean energy, in all Irish waters, covering offshore wind, wave, and tidal (Sustainable Energy Ireland, n.d.).

All of these planning efforts relevant to the development of marine energy are described in more detail in the following sections.

Relevance to the Framework
The cumulative effects framework would function similarly to an environmental assessment. Like an environmental assessment, the framework is tool which displays information on the existing environment and illustrates where significant impacts on the environment might be expected as well as where data gaps exist. The framework differs from environmental assessment in a number of important ways, including being participatory and adaptive, thus being capable of being updated periodically to reflect changing circumstances, policies and opinions.

1.3.1 Programmatic Environmental Impact Statement (EIS) for the US Outer Continental Shelf

The United States Department of the Interior, Minerals Management Service (MMS), has prepared a final programmatic EIS in support of the establishment of a program for authorizing alternative energy and alternate use (AEAU) activities on the Outer Continental Shelf (OCS). The final programmatic EIS examines the potential environmental effects of the program on the OCS and identifies policies and best management practices that may be adopted for the program. The types of alternative energy projects analyzed in detail in the EIS are offshore wind, wave, and ocean current energy capture technologies. The programmatic nature of the EIS requires that the examination of environmental consequences and potential mitigation measures be conducted at a broader scale than would be appropriate for site-specific projects. A product of the process of preparing the programmatic EIS is the development of policies and best management practices that may be adopted as mitigation measures by the AEAU Program.

1.3.2 Scottish Marine Renewables SEA

In support of the development of the marine renewables industry strategic environmental assessment has been carried out for the north and west coast of Scotland (Faber Maunsell/AECom, 2008). It was commissioned by the Scottish Executive to examine the environmental effects of developing wave and tidal power. The primary question addressed in the SEA was whether wave and tidal stream energy could contribute towards helping the Scottish Executive achieve its target for producing 40% of its electricity from renewable sources by 2020 without significant effects on the environment. The first part of the

assessment considered effects of wave and tidal devices on the natural and human environment, including marine birds, marine mammals, benthic ecology, fish and shellfish, commerical fisheries, shipping and navigation, seascape, recreation and tourism, the historic environment, onshore grid connections, protected sites and species, geology and energy extraction, seabed contamination and water quality, disposal areas, cables and pipelines, military exercise areas, and electric and magnetic fields. The second part of the assessment examined how much energy could be available in each of the development areas taking account of the need to minimise environmental effects. Finally, the SEA discussed issues for the future development of wave and tidal power and recommended next steps (Faber Maunsell/AECom, 2008).

The Scottish Government reacted to the Marine Renewables SEA and formed a Partnership called the Marine Energy Spatial Planning Group (MESPG). The MESPG has adopted the following 4 theme approach:
1. Develop Marine Planning / Locational Guidance.
2. Simplify Consenting Procedures.
3. Establish an Environmental Monitoring and Research Strategy.
4. Link to / facilitate Regional Initiatives.

1.3.3 Fundy Tidal Energy SEA

A strategic environmental assessment has been carried out for the Bay of Fundy (OEER Association, 2008). Although this deals with tidal energy the environmental impacts will be similar to those of wave energy.

2 Current work – ongoing strategy development and research

This section summarises some of the most recent research on wave energy and cumulative effects that may be relevant to the development of the framework. Some of the studies in this section are specific to wave energy, while others are specific to wind energy or other renewable energy development, but may be relevant to the development of wave energy.

2.1 Impacts of wave energy development

A list of resources available which address the potential impacts of wave energy development.

> **Michel, J., et al. 2007. *World Wide synthesis and analysis of existing information regarding environmental effects of alternative energy uses on the outer continental shelf.* Herndon, VA: U. S. Department of the Interior, Minerals Management Service.**

This document provides an in depth review of the available literature regarding the environmental impacts of wind, wave and ocean current technologies. This includes a review of current technologies and future trends, public acceptance of existing projects, potential direct, indirect and cumulative environmental impacts of these technologies, previously used mitigation measures, current physical and numerical models for determining environmental impacts and identification of information gaps.

> **Hagerman, G. 2004. Offshore Wave Power in the US: Environmental Issues. EPRI report E2I Global EPRI-007-US**

This report provides a summary of wave energy issues and environmental impacts and benefits for the US.

> **McMurray, G. 2007. "Wave Energy Ecological Effects Workshop Ecological assessment briefing paper." Hatfield Marine Science Center. October 2007. http://hmsc.oregonstate.edu/waveenergy/WaveEnergyEffectsBriefingPaper.pdf (accessed June 10, 2009).**

This briefing paper sets out the technology, the ecological setting and the predicted environmental consequences. The paper aims to provide information for a one and a half day meeting who's aim was to develop "an initial assessment of the potential impacting agents and ecological effects of wave energy development in Oregon's costal ocean; and 2) developing a general conceptual framework of physical and biological relationships that can be applied to assess both specific wave energy projects and cumulative effects of multiple projects."

> **Boehlert, G.W., G.R.McMurray, and C.E. Tortorici (editors). 2008. Ecological effects of wave energy in the Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-92, 174 p.**

Summary papers from a workshop held October 11-12, 2007 which aimed to develop an initial assessment of the potential impacting agents and ecological effects of wave energy development in the coastal ocean and to provide a general framework that could be applied

to specific wave energy projects. Includes reports from breakout groups describing receptors and stressors in the marine environment.

ABPMer. The potential nature conservation impacts of wave and tidal energy extraction by marine renewable developments. Countryside Council for Wales Policy Research Report 06/07., 2006.

This report is a study into the sensitivity of the seascape, marine and coastal species and habitats to marine renewable energy developments. In particular, it highlights the nature conservation issues that exist in Welsh Territorial Waters.

Langhamer, O., 2009, "Wave energy conversion and the marine environment. Colonization patterns and habitat dynamics." Doctoral thesis, Uppsala University, Sweden.

A recent doctoral work presented interaction of a wave energy with the marine environment based on the in-situ observation from a wave energy park located in the Swedish west coast. The study involved ecological studies on macro fauna in surrounding sediments and on colonization of the foundations and buoys, investigation of the effect of wave power concrete foundations on the habitat use by fish, and an examination of the effect of types of wave buoys on biofouling by blue mussels from the consideration of efficiency of wave energy extraction.

Simas, T., A. Moura, R. Batty, G., D. Thompson, J. Norris. 2009. Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact: Uncertainties regarding environmental impacts: A draft. (Deliverable D6.3.1)

In this report the main uncertainties regarding the potential effects of ocean energy schemes are presented considering the main components of the marine wild life and its interactions with the physico-chemical environmental alteration / disturbance provided by the deployment of ocean energy power devices. Future socio-economic uncertainties are also discussed considering the experiences of other offshore technologies.

2.2 Specific Environmental Issues

2.2.1 Birds

Norman, T., Buisson, R., & Askew, N. (2007). *Report on the COWRIE workshop on the cumulative impacts of offshore windfarms on birds.* COWRIE Ltd.

This report outlines recommendations for improving the cumulative impact assessment of the potential effects of offshore windfarms on bird populations. The key source of information for this was from a workshop involving a range of key stakeholders.

2.2.2 Historic Environment

COWRIE. (2008, January). *Guidance for assessment of cumulative impacts on the historic environment from offshore renewable energy.* Retrieved June 2, 2009, from COWRIE (Collaborative Offshore Wind Research Into The Environment):

http://www.offshorewindfarms.co.uk/Pages/Publications/Archive/Cultural_Heritage/Historic_environment_g43354590/

This document provides generic guidance in relation to the survey, appraisal and monitoring of the historic environment during the development of offshore renewable energy projects in the United Kingdom. It covers both the marine and coastal environments and those areas further inland likely to be affected by such developments.

2.2.3 Underwater noise

Richards, S.D., E.J. Harland, and S.A.S. Jones. "Appendic C17 Environmental Report." *The Scottish Government - Marine Renewables SEA.* March 2007. http://www.seaenergyscotland.co.uk/ (accessed June 11, 2009).

This document was published in support of the Scottish Government SEA for marine renewables. It discusses the likely noise outputs from marine renewable energy devices during their operation, and their likely impact on biological receptors in the marine environment. This document focuses on the noise outputs during operation rather than construction and installation.

Austin, M. N. Chorney, J. Ferguson, D. Leary, C. O'Neill, and H. Sneddon. 2009. Assessment of Underwater Noise Generated by Wave Energy Devices. Report to Oregon Wave Energy Trust.

This report details the factors that contribute to ambient noise in near-shore environments and provides an overview of the characteristics of the Oregon coast that influence the ambient noise environment. It lists the potential sources of noise associated with the construction, operation and decommissioning phases for wave energy conversion suitable for use in the Oregon coastal environment. The report also provides a framework for a comprehensive noise assessment program and reports the results of an indicative sound propagation modeling study conducted to provide an introduction to an estimation for noise impact assessments for regulatory approval.

2.2.4 Effect of energy extraction

APMer. (2006). *The potential nature conservation impacts of wave and tidal energy extraction by marine renewable developments.* CCW Policy Research Report 06/07.

This report reviews the information that is available on the degree, and extent of, change that may be associated with wave and tidal energy developments. It also discusses the effects that these changes may have on habitats and species which may be affected by such a change in energy.

2.2.5 EMF

Gill, A.B., Gloyne, Phillips, I., Neal, K.J. & Kimber, J.A. (2005). The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review. Final Report to Cowrie. (COWRIE-EM FIELD 2-06-2004). http://www.offshorewindfarms.co.uk/Assets/COWRIE_Final_compiled.pdf

This report provides a comprehensive review and analysis of all information currently available with respect to EMF and offshore wind farm developments. The review presents up-to-date information on the biology of EMF sensitive species, showing that there are many fish species within UK waters which are potentially capable of responding to anthropogenic sources of EMF. However, it is not known whether the interactions between the fish and the artificial EMF will have any consequences for the fish. The report also provides a collation of infromation from the offshore wind farm industry.

2.2.6 Cumulative Effects Analysis

Gilliland, P. M., P.M. Rogers, and J.P. Crutchfield Z. Hamer. "The practical implementation of marine spatial planning - understanding and addressing cumulative effects. Report of a workshop held 4 December 2003, Stansted." ***English Nature Research Reports No. 599.*** **Peterborough: English Nature, 2004.**

Report from a workshop which looks at the relationship between cumulative effects assessment, strategic environmental assessment, environmental impact assessment and marine spatial planning.

Halpern B.S., M. K. (2008). Managing for cumulative impacts in ecosystem-based management through ocean zoning. ***Ocean and Coastal Management*** **(51), 203-211.**

Journal article which discusses in general terms how the evaluation of interactive and cumulative impacts should be approached and how ocean zoning may be used as a tool for managing cumulative impacts.

Walker L. J., J. J. (2001). ***Guidelines for the assessment of indirect and cumulative impacts as well as impact interations.*** **Luxembourg: Office of Official publications of the European Communities.**

This report provides guidelines for practitioners of EIA (environmental impact assessment) on how to approach cumulative and indirect impacts, as well as impact interactions during the various stages of EIA. Methods and tools for assessing indirect and cumulative impacts, as well as impact interactions are also suggested and compared.

Council on Environmental Quality. "Considering Cumulative Effects Under the National Environmental Policy Act." ***NEPAnet.*** **January 1997. http://ceq.hss.doe.gov/NEPA/ccenepa/ccenepa.htm (accessed June 24, 2009).**

Chapter 5 of this document describes methods, techniques, and tools for analyzing cumulative effects, including questionnaires, interviews and panels, checklists, matrices, network and system diagrams, modeling, trend analysis and GIS.

U.S. Environmental Protection Agency. "National Environmental Policy Act (NEPA) Policies & Guidance." ***United States Environmental Protection Agency.*** **May 1999. http://www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf (accessed June 8, 2009).**

This document provides guidelines to assist EPA reviewers of NEPA documents on how cumulative impacts should be handled within NEPA documents. In particular, it provides guidance on the definition of cumulative impacts, spatial and temporal boundaries, and the use of thresholds to assess resource degradation.

2.3

2.4 Other papers and reports

Campbell, Holly V. 2009. A Rising Tide: Wave Energy in the United States and Scotland. Sea Grant Law and Policy Journal, Vol. 2, No. 2 (Winter 2009/2010): 29-48.

Compares the present status and context of wave energy, in the U.S. and Scotland. Compares the two nations' procedures for licensing wave energy devices and identifies factors that appear to contribute to the development of a wave energy industry in ways that are reasonably timely, as well as environmentally and economically prudent.

Simas, T., A. Moura, R. Batty, G. Vernont, M. Paillard, C. Abonnel, D. Thompson, J. Norris. 2009. Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact: Existing legislation, perspectives and evolution of other similar technologies. Draft Report (Deliverable D6.1.1).

This report includes a revision of the legal instruments regarding the environmental requirements of the consent procedure for ocean energy schemes in European Union, its Member States and other countries where tidal and wave energy schemes are operating. The perspective of incoming future European legislation (e.g. the role of the Water Framework Directive and the future Marine Directive) in the development of ocean energy schemes is discussed and examples of legislation requirements for other technologies such as offshore wind are presented in order to find similarities.

Lavrakas, John and Jed Smith. 2009. Wave energy infrastructure assessment in Oregon. Report to the Oregon Wave Energy Trust (December 1, 2009).

Assesses the infrastructure needs of ocean renewable energy and compares those needs against the existing and planned infrastructure capabilities in Oregon. Summarizes the results of the assessment performed by Advanced Research Corporation. Identifies a set of prioritized, recommended actions to resolve infrastructure gaps, thereby supporting the development of wave energy products and services in Oregon.

3 Research themes and programmes

This section describes programs that have ongoing work in the area of wave energy development. Through the work of these programs, the potential exists to inform future iterations of the framework that will be developed during this stage of the project, Phase I. In addition, Appendix A describes various wave energy organizations supporting research into development of marine renewable energy that have been established across the world.

3.1 US Department of Energy (DOE)

Out puts from the following specific market acceleration projects/initiatives, being carried out through the US Department of Energy (DOE)'s Water Power Program FY 2008 Advanced Water Power Projects (US Dept of Energy, 2010) could provide input to a cumulative effects framework that is being developed through this OWET funded project:

Wave Energy Resource Assessments and GIS Database for the US - this project is being carried out by the Electrical Power Research Institute. The deliverables of this project will include available wave energy resources at 3 nautical miles offshore of State of Oregon and at two depth contours, at 50 m and 200m (approximate edge of continental shelf).

A report to US Congress *On the potential environmental impacts marine energy projects, including wave energy,* has been prepared by the Oak Ridge National Laboratory in response to the Section 633 (b) of the Energy Independence and Security Acts of 2007 (EISA). The report discusses relevant impacts on water quality, aquatic habitats and organisms, options to prevent adverse impacts, potential roles of environmental monitoring and adaptive management in mitigating impacts, necessary component of an adaptive management program (Oak Ridge National Laboratory, 2009).

Identification of potential navigational impacts and mitigation measures – this project is being carried out by PCCI Inc., VA. The scope of the deliverables from this project includes development of a framework for assessing, identifying, and describing potential navigational hazards of marine energy systems, including wave energy. The framework will include development of a hazard checklist.

The Pacific Energy Ventures from Portland, OR is carrying out a project on *Siting protocol for marine energy projects* that will provide improved guidance to help wave energy developers understand potential regulatory issues including siting framework for wave energy project development in Oregon, based on stakeholder engagement process.

Re Vision Consulting of Sacramento, CA is developing an assessment framework through a project *"Best siting practices for Marine…"* applicable to wave energy projects, considering generic environmental issues and site-specific challenges, such as, conflicting uses and navigational hazard. The scope involves establishment of baseline scenarios for two wave power sites and using different technologies.

The DOE water power program has also commissioned the Pacific North West National Laboratory (PNNL) to provide research support, outreach and coordination with various stakeholders for various activities, including spatial planning, environmental assessment & monitoring associated with marine energy. PNNL has been also identified to provide support to the DOE for the IEA-OES Annex IV environmental data assessment.

3.2 Electric Power Research Institute (EPRI)

The Electric Power Research Institute, Inc. (EPRI) is a US-based institute that conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its

scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries. EPRI has produced a number of reports on wave and tidal energy topics.

3.3 International Energy Agency Ocean Energy Systems Implementing Agreement (IEA-OES)

The International Energy Agency (IEA) has established Implementing Agreements to provide a framework for international collaboration in energy technology R&D, demonstration and information exchange. The IEA Ocean Energy Systems Implementing Agreement (IEA-OES) was launched in 2001 in response to increased activity in the development of ocean wave and tidal current energy primarily in Denmark, Portugal and the United Kingdom, and the desire for technology cooperation. There are 17 countries that have signed this agreement, with the inaugural signatories being Denmark, Portugal, and the UK. The U.S. DOE became a signatory in 2005.

There are four collaborative annexes, or tasks, under the IEA-OES.

- Annex I - Review, Exchange and Dissemination of Information on Ocean Energy Systems
- Annex II - Development of Recommended Practices for Testing and Evaluating Ocean Energy System
- Annex III - Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids
- Annex IV - Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal, and Current Energy Systems

Annex IV of the IEA-OES is to develop an assessment of environmental effects and monitoring efforts for ocean wave, tidal, and current energy systems. The objective of this task is to increase understanding of the environmental effects of ocean wave, tidal and current energy development on the marine environment. Depending on the extent of information available, examples of environmental impacts for potential consideration may include impacts to benthic organisms, fish, marine mammals, birds, sediment transport and coastal processes, multiple uses, visual impacts, social impacts and economics, among others. Before analysis begins, Annex members will determine which impacts should be included to ensure that efforts are focused on priority needs.

This task began in 2009, and will culminate in an accessible and searchable database, an expert's workshop, and a comprehensive summary report that will be published by the IEA-OES in 2011. The report will present all relevant information gathered, provide critical analysis on monitoring efforts and mitigation, and provide guidance to international ocean energy stakeholders including policymakers, developers, regulators, agencies, academic institutions, and research organizations.

3.4 Minerals Management Service Environmental Studies Program (US)

The Office of Offshore Renewable Energy Programs of the Minerals Management Service (MMS) oversees development of offshore renewable energy projects on the Outer Continental Shelf (OCS). The Bureau's responsibilities include determining and evaluating the effects of OCS activities on natural, historical, and human resources and the appropriate monitoring and mitigating of those effects. The MMS have conducted a Programmatic

EIS in support of the establishment of a program for authorizing alternative energy and alternate use (AEAU) activities on the Outer Continental Shelf (described above) and they have also completed a "Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Renewable Energy on the Outer Continental Shelf Report" (Michel, 2007).
Some ongoing studies include:

- Effects of Pile Driving Sounds on Auditory and Non-Auditory Tissues of Fish
- Update of Summary of Knowledge: Selected Areas of the Pacific Coast
- Compendium of Avian Information and Comprehensive GIS Geodatabase
- Energy Market and Infrastructure Information for Evaluating Renewable Energy Projects for OCS Atlantic and Pacific Regions
- Meteorological and Wave Measurements for Improving Meteorological and Air Quality Modeling

3.5 Marine Renewable Energy Research Advisory Group (UK)

The Marine Renewable Energy Research Advisory Group is a subset of the Research Advisory Group (RAG) created by the U.K. Department for Business, Enterprise and Regulatory Reform (BERR) as a pan-government body to facilitate a coordinated approach among the regulatory and funding bodies to address the key impact issues of wind farm proposals. The remit of RAG was extended to gain further understanding on the potential impacts of wave & tidal power generation and BERR allocated a further budget of up to £2 million to concentrate on these emerging technologies. The terms of reference of RAG include issues associated with offshore wind and wave and tidal stream power generation.
The Marine Renewable Energy Research Advisory Group published the Wave and tidal stream energy monitoring and research strategy in 2006. Its objective is to ensure that critical environmental information (covering baseline, impact and mitigation) is collected during the demonstrator phase of wave and tidal stream technology deployment, to inform strategic decisions on future leasing rounds and consenting of individual developments.
Some of the priorities identified in this strategy include:

- Energy removal
- Tidal flow effects of energy removal
- Sediment & seabed effects of energy removal
- Faunal collision with rotor or vane
- Operational acoustic emissions
- Characteristics of operational vibration
- Functional importance of areas to mobile species
- Navigation impacts
- Impacts on other users (fishing & recreational use)

3.6 UK Fisheries Research Service

The UK Fisheries Research Service published a Strategic research assessment for wet renewables in 2008. The purpose of this report is to develop proposals for strategic research activities that would encourage the development of power generation from wet renewable sources (wave and tidal power) in Scottish coastal waters, particularly those that address environmental questions (Davies, 2008). This report also gives details of the current research activities related to wave and tidal power generation in the UK. According to this report, the two main research and development objectives should be the development of a computer-based spatial planning system (GIS system) linking environmental characteristics with opportunities and constraints influencing development potential, and the development of a template and guidance document for the preparation of Environmental Impact Statements for wave and tidal energy projects.

3.7 European Marine Energy Centre (EMEC)

The European Marine Energy Centre (EMEC) offers developers the opportunity to test full scale grid connected prototype devices in exposed wave and tidal conditions. For most developers coming to deploy at EMEC, installation at these facilities will be the first time their device has been in the open sea and grid connected. They typically will not have a track record which indicates the type and extent of interactions between the device and the receiving environment. Therefore, whilst the central purpose of EMEC is to provide an operational test facility, there is also a key role in establishing and facilitating monitoring of devices in relation to their impacts on the receiving environment. The main driver to this has been through the consenting process which requires developers to consider environmental issues prior to testing at EMEC, and to mitigate against any potential for negative impact. Project details available on the website - http://www.emec.org.uk/research.asp

3.8 SUPERGEN consortium project

SUPERGEN Marine is a large international academic based consortium whose objective is to increase knowledge and understanding of device-sea interactions of energy converters from model-scale in the laboratory to full size in the open sea.

Phase 1 began in 2003 and delivered an enhanced understanding of the extent and nature of the marine resources, how extraction of energy modifies that resource and its environment, and has pointed to how technology could be developed to enhance the effective exploitation of energy.

Phase 2 began in 2008 with priorities proposed to build on experiences and questions arising from early device tests, the deployment of prototype devices, the UKERC R&D road-mapping and DTI Protocol processes, and the outcomes of the original work program. Phase 2 of the program includes work on: device arrays and how these will influence local and regional environmental conditions; radical design approaches, which take into account new philosophies of design guidance; ensuring that numerical and physical design support is consistent and robust; the challenges posed by design in mixed tidal and wave environments; system control in complex non linear and evolving environments; the complex challenges posed by fixing, mooring and recovery of marine systems; the economic challenges posed by the variable and intermittent nature of the marine resource; the sparse information available to predict and assess the long term reliability of marine energy systems and how an increased understanding of all of these issues can be best disseminated within the stakeholder community.
http://www.supergen-marine.org.uk/news.php

3.9 Marine Renewable Energy Development in Scotland Consortium (MREDS)

The prime objective of the MREDS programme is to seek ways of strengthening the marine renewables sector in Scotland. MREDS seeks to achieve this prime objective in four ways:

1. Seeking innovative short, medium and long term solutions to possible constraints to the conventional export infrastructure;
2. Attempting a broad-scale cross fertilisation between the marine petroleum and marine renewables sectors, including exchanges and sharing of approaches to best practice and innovation;
3. Identifying and proposing solutions to the management of issues associated with development risk, and in particular investment and insurance risks;
4. Ensuring that environmental and social issues are tackled proactively and to the satisfaction of stakeholder interests.

MREDS launched in May 2007 and will run for 5 years, being lead through The International Centre for Islands Technology (ICIT), a department of Scotland's Heriot-Watt University based in Orkney.

http://www.mreds.co.uk/

3.10 Marine Energy Spatial Planning Group (MESPG) research work streams

Scottish Government reacted to the Marine Renewables SEA and formed a Partnership with main players, the MESPG. MESPG has adopted the following 4 theme approach:

1. Develop Marine Planning / Locational Guidance.
2. Simplify Consenting Procedures.
3. Establish an Environmental Monitoring and Research Strategy.
4. Link to / facilitate Regional Initiatives.

Progress made by MESPG will be reviewed in light of the Marine Bill outcomes.

3.11 Marine Renewable Energy and the Environment (MaREE)

The Environmental Research Institute-North Highland College (ERI), in partnership with the Scottish Association for Marine Science (SAMS), has secured funding for a project to develop a sustainable programme of applied and fundamental research in the development of marine renewable. The MaREE project aims to explore the environmental issues related to marine renewable energy development in the Highlands & Islands and socio-economics internal to the region. The programme seeks to build on existing expertise in marine environmental sciences and the unique resource potential of the region in order to develop an integrated, holistic understanding of the environmental considerations surrounding marine renewable energy development in Scotland.

3.12 Marine Alliance for Science & Technology for Scotland (MASTS)

The Marine Alliance for Science & Technology for Scotland (MASTS) pools the research talent, involving about 700 researchers, and the management of resources, consisting of over £66 million annually, in marine science from across Scotland. It strives to ensure that marine science in Scotland can remain internationally competitive. It provides the academic platform and knowledge for marine governance and commerce by helping to establish a Scottish strategy for marine science that will deliver increased value to the public from its investments. Of the nine joint research themes, marine renewable energy will form part of the MASTS research agenda.
http://www.masts.ac.uk/

3.13 Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact (EquiMar)

The EquiMar project is funded by the European Commission as part of its 7th Framework programme under the Energy topic. It is a collaborative research and development project involving a consortium of 23 partners and will run for three years from the 15th of April 2008.

The aim of EquiMar is to deliver a suite of protocols for the equitable evaluation of marine energy converters (based on either tidal or wave energy). These protocols will harmonise testing and evaluation procedures across the wide variety of devices presently available with the aim of accelerating adoption though technology matching and improved understanding of

the environmental and economic impacts associated with the deployment of arrays of devices. EquiMar will assess devices through a suite of protocols covering site selection, device engineering design, the scaling up of designs, the deployment of arrays of devices, the environmental impact, in terms of both biological & coastal processes, and economic issues. A series of protocols will be developed through a robust, auditable process and disseminated to the wider community. Results from the EquiMar project will establish a sound base for future marine energy standards.
http://www.equimar.org/

3.14 Energy Technologies Institute (ETI)

The Energy Technologies Institute (ETI) is a UK-based company formed from global industries and the UK government. The ETI will demonstrate technologies, develop knowledge, skills and supply-chains, inform the development of regulation, standards and policy, and so accelerate the deployment of affordable, secure low-carbon energy systems from 2020 to 2050.

Within the wave sector, their priorities include:

- •Design, development and testing of prototypes under relevant conditions ready for testing, perhaps at EMEC, Wave Hub or NaREC.
- •Design development and testing of key sub-systems (including foundations and/or moorings systems) and component technologies optimised for the marine renewable sector.
- •Studies to assess practical device and array performance.
- •Studies to understand positive and negative environmental impacts, including sediment transfer.

http://www.energytechnologies.co.uk/Home.aspx

3.15 Hydraulics and Maritime Research Centre (Ireland)

The HMRC at University College Cork in Ireland offers independent advice and support to developers through model testing, concept design, computer modeling, design performance validation, resource assessments and offshore data recording. All research undertaken at the HMRC attempts to take into account the impact upon the environment. The centre aims to continue to move forward particularly in the area of applied research and product development.

3.16 Norwegian University of Science and Technology NTH/NTNU

The Norwegian University of Science and Technology in Trondheim (Falnes, 2008) is involved in several research and development projects relating to wave, including the EU-sponsored SEEWEC project. Statkraft AS, a state-owned utility, has launched an ocean energy university programme focusing on offshore wind, wave and tidal energy, including three Nordic universities (NTNU, Norway; University of Uppsala, Sweden; and DTU, Denmark). Statkraft has allocated EuR 10 million for a period of four years, and the universities will match the projects financed by the programme to double the effort. “Wind&Ocean” is a multiclient programme for Norwegian SMEs with international growth ambitions. It is a co-funded programme between Innovation Norway and the participants, and consists of market research, business development and networking opportunities. The main focus is Western Europe and the companies are mainly technology developers in the wave, tidal and wind sectors (IEA-OES 2008).

3.17 New Zealand Wave Energy Technology Research and Development Programme (WET-NZ)

The New Zealand government has provided research and development funding to three marine energy projects over last four years. Principal beneficiary is the Wave Energy Technology – New Zealand (WET-NZ) consortium, which comprises two Crown Research Institutes (Industrial Research limited (IRI) and the National Institute for Water and Atmospheric Research (NIWA) and a private company, Power Projects limited. The project seeks to develop a wave energy device that maximises engineering efficiency through the novel use of direct-drive and adaptive response to changes in wave motion. The device will be largely sub-surface so that as much of the device as possible interacts directly with the wave energy. A second 2 kW prototype will be deployed in open-ocean conditions in early 2009.

4 Literature cited

ABPMer. 2006. *The potential nature conservation impacts of wave and tidal energy extraction by marine renewable developments*. Countryside Council for Wales Policy Research Report 06/07.

AECom. 2009. *Pentland Firth and Orkney Waters Marine Spatial Plan (MSP) Framework and*
Regional Locational Guidance (RLG) for Marine Renewable Energy: Consultation Document. Prepared for the Scottish Government (Marine Scotland). May 2009. 122 pp. http://www.scotland.gov.uk/Resource/Doc/274332/0082049.pdf)

Austin, M. N. Chorney, J. Ferguson, D. Leary, C. O'Neill, and H. Sneddon. 2009. *Assessment of Underwater Noise Generated by Wave Energy Devices.* Report to Oregon Wave Energy Trust.

Australian Government Department of the Environment, Water, Heritage, and the Arts. 2009. *Marine Bioregional Planning*. Retrieved October 26, 2009, from Australian Government Department of the Environment, Water, Heritage, and the Arts: http://www.environment.gov.au/coasts/mbp/index.html

Beaufort Sea Partnership. n.d. *Beaufort Sea Large Ocean Management Area*. Retrieved October 26, 2009, from Beaufort Sea Partnership: http://www.beaufortseapartnership.ca/bslom.html

Boehlert, G.W., G.R.McMurray, and C.E. Tortorici (editors). 2008. *Ecological effects of wave energy in the Pacific Northwest.* U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-92, 174 p.

Bundesamt für Seeschifffahrt und Hydrographie (BSH). 2009. *Spatial Planning in the German EEZ*. http://www.bsh.de/en/Marine_uses/Spatial_Planning_in_the_German_EEZ/index.jsp. Retrieved on 2009-10-26.

Campbell, Holly V. 2009. *A Rising Tide: Wave Energy in the United States and Scotland.* Sea Grant Law and Policy Journal, Vol. 2, No. 2 (Winter 2009/2010): 29-48.

Common Wadden Sea Secretariat. 2009. *The Trilateral Cooperation on the Protection of the Wadden Sea* . Retrieved October 26, 2009, from Common Wadden Sea Secretariat: http://www.waddensea-secretariat.org/

Common Wadden Sea Secretariat. 1997. *Trilateral Wadden Sea Plan.* Retrieved October 26, 2009, from Common Wadden Sea Secretariat: http://www.waddensea-secretariat.org/management/Plan.html

COWRIE. 2008. *Guidance for assessment of cumulative impacts on the historic environment from offshore renewable energy.* Retrieved June 2, 2009, from COWRIE (Collaborative Offshore Wind Research Into The Environment): http://www.offshorewindfarms.co.uk/Pages/Publications/Archive/Cultural_Heritage/Historic_environment_g43354590/

Council on Environmental Quality. 1997. *Considering Cumulative Effects Under the National Environmental Policy Act. NEPAnet.* January 1997. http://ceq.hss.doe.gov/NEPA/ccenepa/ccenepa.htm (accessed June 24, 2009).

Davies, Ian. 2008. *Strategic Research Assessment for Wet Renewables.* Fisheries Research Services. Aberdeen: Fisheries Research Services.

DEFRA. 2009. *Marine and Coastal Access Act 2009*. Retrieved January 21, 2010, from DEFRA: http://www.defra.gov.uk/environment/marine/legislation/index.htm

Dutch Ministry of Transport, Public Works and Water Management. 2005. *Integrated Management Plan for the North Sea 2015.* Interdepartmental Directors' Consultative Committee North Sea. http://www.unesco-ioc-marinesp.be/uploads/documentenbank/4cf76ef0978d9e21b00ffa0460eb0221.pdf. Accessed on 2009-10-26.

Faber Maunsell/AECom. 2008. *The Scottish Government Marine Renewables SEA*. Retrieved October 26, 2009, from The Scottish Government Marine Renewables SEA: http://www.seaenergyscotland.co.uk/

Falnes, J. 2008. *Wave Energy Research*. Retrieved October 26, 2009, from Johannes Falnes' Home Page: http://folk.ntnu.no/falnes/w_e/index-e.html

Fisheries and Oceans Canada. 2009. *Large Ocean Management Areas*. Retrieved October 26, 2009, from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/oceans/marineareas-zonesmarines/loma-zego/index-eng.htm

Fisheries and Oceans Canada. 2008. *Introduction to the ESSIM Initiative*. Retrieved October 26, 2009, from Fisheries and Oceans Canada: http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/essim-intro-e.html

Fisheries and Oceans Canada. 2007. *Eastern Scotian Shelf Integrated Ocean Management Plan.* Fisheries and Oceans Canada, Oceans and Habitat Branch, Dartmouth, Nova Scotia.

Gill, A.B., Gloyne, Phillips, I., Neal, K.J. & Kimber, J.A. 2005. *The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review.* Final Report to Cowrie. (COWRIE-EM FIELD 2-06-2004). http://www.offshorewindfarms.co.uk/Assets/COWRIE_Final_compiled.pdf

Gilliland, P. M., P.M. Rogers, and J.P. Crutchfield Z. Hamer. 2004. *The practical implementation of marine spatial planning - understanding and addressing cumulative effects. Report of a workshop held 4 December 2003, Stansted*. *English Nature Research Reports No. 599.* Peterborough: English Nature.

Hagerman, G. 2004. *Offshore Wave Power in the US: Environmental Issues*. EPRI report E2I Global EPRI-007-US.

Halpern B.S., M. K. 2008. *Managing for cumulative impacts in ecosystem-based management through ocean zoning.* Ocean and Coastal Management (51), 203-211.

IEA-OES. 2008. *2008 Annual Report, International Energy Agency Implementing Agreement on Ocean Energy Systems (IEA-OES),* edited by A. Brito-Melo and G. Bhuyan, February 2009. Accessed at: http:/www.iea-oceans.org/publications.asp?id=1.

Interagency Ocean Policy Task. 2009. *Interim Framework for Effective Coastal and Marine Spatial Planning.* Washington, DC: White House Council on Environmental Quality: http://www.whitehouse.gov/sites/default/files/microsites/091209-Interim-CMSP-Framework-Task-Force.pdf

Langhamer, O., 2009, *Wave energy conversion and the marine environment:. Colonization patterns and habitat dynamics*. Doctoral thesis, Uppsala University, Sweden.

Lavrakas, John and Jed Smith. 2009. *Wave energy infrastructure assessment in Oregon.* Report to the Oregon Wave Energy Trust (December 1, 2009).

Marine Spatial Planning Initiative. 2009. *United States: Massachusetts*. http://www.unesco-ioc-marinesp.be/msp_practice/united_states_massachusetts. Retrieved on 2009-10-26.

McMurray, G. 2007. *Wave Energy Ecological Effects Workshop Ecological assessment briefing paper*. Hatfield Marine Science Center. October 2007. http://hmsc.oregonstate.edu/waveenergy/WaveEnergyEffectsBriefingPaper.pdf (accessed June 10, 2009).

Michel, J., et al. 2007. *World Wide synthesis and analysis of existing information regarding environmental effects of alternative energy uses on the outer continental shelf.* Herndon, VA: U. S. Department of the Interior, Minerals Management Service.

NOAA Office of Ocean and Coastal Resource Management. 2009. *Ocean and Great Lakes Resources: Case Studies*. http://coastalmanagement.noaa.gov/issues/or_casestudies.html#8. Retrieved on 2009-10-26.

Norman, T., Buisson, R., & Askew, N. 2007. *Report on the COWRIE workshop on the cumulative impacts of offshore windfarms on birds.* COWRIE Ltd.

Oak Ridge National Laboratory. 2009. *EISA Report to Congress*. Retrieved April 2010, from Oak Ridge National Laboratory: http://www.ornl.gov/sci/eere/EISAReport/report.html

OEER Association. 2008. *Fundy Tidal Energy Strategic Environmental Assessment Final Report.* Nova Scotia Department of Energy.

Oregon Coastal Management Program. 1994. *Oregon Territorial Sea Plan.* http://www.oregon.gov/LCD/OCMP/Ocean_TSP.shtml. Retrieved on 2009-10-26.

Oregon Coastal Management Program. 2008. *Ocean Resources*. (February 1, 2008) http://www.oregon.gov/LCD/OCMP/Ocean_Intro.shtml. Retrieved on 2009-10-26.

Oregon Department of Land Conservation and Development. 2009. *Oregon Territorial Sea Plan Part Five: Use of the Territorial Sea for the Development of Renewable Energy Facilities or Other Related Structures, Equipment or Facilities.* Adopted 11/5/2009. 19 pp. http://www.oregon.gov/LCD/tspac.shtml

Powertech Labs Inc. 2008. *An assessment of variable characteristics of the Pacific Northwest Region's wave and tidal current power resources, and their interaction with electricity demand & implications for large scale development scenarios for the region – Phase 1.* Report for Bonneville Power Administration, British Columbia Hydro, British Columbia Transmission Corporation. (January 2008).197 pp.

Richards, S.D., E.J. Harland, and S.A.S. Jones. 2007. *Appendic C17 Environmental Report.* The Scottish Government - Marine Renewables SEA. (March 2007). http://www.seaenergyscotland.co.uk/ (accessed June 11, 2009).

The Scottish Government. 2010. *Marine Bill*. Retrieved January 21, 2010, from The Scottish Government: http://www.scotland.gov.uk/Topics/marine/16440/marine-bill-consultation

Simas, T., A. Moura, R. Batty, G. Vernont, M. Paillard, C. Abonnel, D. Thompson, J. Norris. 2009. *Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact: Existing legislation, perspectives and evolution of other similar technologies. Draft Report* (Deliverable D6.1.1).

Simas, T., A. Moura, R. Batty, G., D. Thompson, J. Norris. 2009. *Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact: Uncertainties regarding environmental impacts: A draft.* (Deliverable D6.3.1)

Sustainable Energy Ireland. (n.d.). *Offshore Renewable Energy SEA*. Retrieved October 26, 2009, from SEI - Sustainable Energy Ireland: http://www.sei.ie/Renewables/Ocean_Energy/Offshore_Renewable_SEA/

US Dept of Energy. 2010. *Wind and Water Power Program*. (2010, February 25). Retrieved April 2010, from US Dept of Energy: Energy Efficiency and Renewable Energy: http://www1.eere.energy.gov/windandhydro/

UNESCO. 2009. *Marine Spatial Planning (MSP)*. (2009, August 20).Retrieved October 26 , 2009, from Marine Spatial Planning Initiative: http://www.unesco-ioc-marinesp.be/marine_spatial_planning_msp

UNESCO. 2010. *Norway*. (2010, January 20). Retrieved January 21, 2010, from Marine Spatial Planning Initiative: http://www.unesco-ioc-marinesp.be/spatial_management_practice/norway

USDI Minerals Management Service. n.d.. *OCS Alternative Energy and Alternate Use Programmatic EIS Information Center*. Retrieved October 26, 2009, from OCS Alternative Energy and Alternate Use Programmatic EIS Information Center: http://ocsenergy.anl.gov/index.cfm

U.S. Environmental Protection Agency. 1999. *National Environmental Policy Act (NEPA) Policies & Guidance.* United States Environmental Protection Agency. May 1999. http://www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf (accessed June 8, 2009).

Walker L. J., J. J. 2001. *Guidelines for the assessment of indirect and cumulative impacts as well as impact interations.* Luxembourg: Office of Official publications of the European Communities.

Appendix A: Wave Energy Organizations

Country	Name	Role	Link
International	IEA-OES	Their mission is to "To facilitate and co-ordinate ocean energy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialization of sustainable, efficient, reliable, cost-competitive and environmentally sound ocean energy technologies."	http://www.iea-oceans.org/
New Zealand	AWATEA	The Aotearoa Wave and Tidal Energy Association (AWATEA) was established in April 2006 to promote the uptake of marine energy in New Zealand.	http://www.awatea.org.nz/
Portugal	WavEC	The Wave Energy Centre (WavEC) is a non-profit organisation, founded in 2003 dedicated to the development and promotion of Ocean Wave Energy.	
Denmark	Bølgekraftforeningen (Danish Wave Energy Society)	[Page is under translation]	http://www.waveenergy.dk/
Ireland	The Marine Renewables Industry Association (MRIA)	Launched on 21st April 2009. It was set up to represent the interest of the business in Ireland engaged in the development of wave and tidal energy projects.	No website available yet
Ireland	Ocean Energy Development Unit	Sustainable Energy Ireland (SEI) is Ireland's national energy agency. The Ocean Energy Development Unit has been established to implement the Government's policy decision to accelerate the development of Ocean Energy (Wave and Tidal) in Ireland.	http://www.sei.ie/Renewables/Ocean_Energy/Ocean_Energy_Development_Unit/
Canada	Ocean Renewable Energy Group (OREG)	A non-profit organization set up with the aim of realizing Canada's ocean energy resources, technologies, and project capabilities	http://www.oreg.ca/
Canada	The Offshore Energy Environmental Research Association (OEER)	A non-profit organisation dedicated to fostering offshore energy and environmental research and development.	http://www.offshoreenergyresearch.ca/
UK	RenewableUK	Formerly BWEA, the British Wind Energy Association, RenewableUK is the trade and professional body for the UK wind and marine renewables industries. They act as a central point for information for their membership and as a lobbying group to promote wind energy and marine renewables to government.	http://www.bwea.com/marine/index.html